GCE

Physics A

H156/02: Depth in physics

Advanced Subsidiary GCE

Mark Scheme for June 2019

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Here are the subject specific instructions for this question paper.

CATEGORISATION OF MARKS

The marking schemes categorise marks on the MACB scheme.

B marks These are awarded as independent marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answer.

M marks These are method marks upon which **A**-marks (accuracy marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answer. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

C marks These are compensatory method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

A marks These are accuracy or answer marks, which either depend on an **M**-mark, or allow a **C**-mark to be scored.

SIGNIFICANT FIGURES

If the data given in a question is to 2 sf, then allow an answer to 2 or more significant figures.
If an answer is given to fewer than 2 sf, then penalise once only in the entire paper.
Any exception to this rule will be mentioned in the Guidance.

Annotations available in RM Assessor

Annotation		Meaning
	Correct response	Used to indicate the point at which a mark has been awarded (**one tick per mark awarded**).
	Incorrect response	Used to indicate an incorrect answer or a point where a mark is lost.
AE	Arithmetic error	Do not allow the mark where the error occurs. Then follow through the working/calculation giving full subsequent ECF if there are no further errors.
BOD	Benefit of doubt given	Used to indicate a mark awarded where the candidate provides an answer that is not totally satisfactory, but the examiner feels that sufficient work has been done.
BP	Blank page	Use BP on additional page(s) to show that there is no additional work provided by the candidates.
CON	Contradiction	No mark can be awarded if the candidate contradicts himself or herself in the same response.
ECF	Error carried forward	Used in numerical answers only, unless specified otherwise in the mark scheme. Answers to later sections of numerical questions may be awarded up to full credit provided they are consistent with earlier incorrect answers. Within a question, ECF can be given for AE, TE and POT errors but not for XP.
L1	Level 1	L1 is used to show 2 marks awarded and L1^ is used to show 1 mark awarded.
L2	Level 2	L2 is used to show 4 marks awarded and L2^ is used to show 3 marks awarded.
L3	Level 3	L3 is used to show 6 marks awarded and L3^ is used to show 5 marks awarded.
POT	Power of 10 error	This is usually linked to conversion of SI prefixes. Do not allow the mark where the error occurs. Then follow through the working/calculation giving ECF for subsequent marks if there are no further errors.
SEEN	Seen	To indicate working/text has been seen by the examiner.
SF	Error in number of significant figures	Where more SFs are given than is justified by the question, do not penalise. Fewer significant figures than necessary will be considered within the mark scheme. **Penalised only once in the paper.**
TE	Transcription error	This error is when there is incorrect transcription of the correct data from the question, graphical read-off, formulae booklet or a previous answer. Do not allow the relevant mark and then follow through the working giving ECF for subsequent marks.
XP	Wrong physics or equation	Used in numerical answers only, unless otherwise specified in the mark scheme. Use of an incorrect equation is wrong physics even if it happens to lead to the correct answer.
^	Omission	Used to indicate where more is needed for a mark to be awarded (what is written is not wrong but not enough).

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
/	alternative and acceptable answers for the same marking point
reject	Answers which are not worthy of credit
not	Answers which are not worthy of credit
ignore	Statements which are irrelevant
allow	Answers that can be accepted
( )	Words which are not essential to gain credit
___	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Question			Answer	Marks	Guidance
1	(a)	(i)	$\frac{\Delta v}{\Delta t}$ and $\Delta t \geq 0.20$ s	M1	**Allow** tolerance of ±½ a small square e.g. $\frac{4.7(-0)}{0.48(-0)} = 9.79$
			9.8 m s^{-2}	A0	
		(ii)	4.7 or $\frac{1}{2} \times 0.057 \times v^2$	M1	
			$\frac{1}{2} \times 0.057 \times 4.7^2 = 0.629565$	M1	
			0.63 J	A0	
	(b)	(i)	0.8 x 0.63 J (0.504 J) OR $v^2 = \frac{2 \times \text{KE}}{0.057}$	C1	**Allow** one mark for correct rearrangement of KE equation with incorrect KE
			$v^2 = \frac{2 \times 0.504}{0.057}$	C1	17.684
			4.2(1) (ms^{-1})	A1	
		(ii)	Straight line from (0.48, –4.2) to *x*-axis and plotted to ±½ small square	C1	**Allow ECF** from **(b)(i)** **Allow** (0.49, –4.2) / (0.50, –4.2) / (0.51, –4.2) / (0.52, –4.2)
			x-axis intercept at *t* = 0.91 ± 0.03 (s) from negative *v*	A1	**Allow ECF** for incorrect negative *v*
		(iii)	area under the graph = $\frac{1}{2} \times 4.2 \times 0.43$	C1	**Allow ECF** from **(b)(i) and (b)(ii)** **Allow** use of equation of motion: e.g. $s = \frac{4.2^2}{2 \times 9.81}$ or $s = (-4.2 \times 0.43) + \frac{1}{2} \times 9.81 \times 0.43^2$ (numbers must be seen) **Allow** use of loss of KE = gain in PE
			0.90 (m)	A1	**Allow** one significant figure **Note** 0.84 for Δ*t* = 0.40 to 0.97 for Δ*t* = 0.46
	(c)		Line will curve / be non-linear OR (magnitude of) gradient of line decreases (with increase in time)	B1	**Allow** sketch or gradient decreases / changes **Not** gradient is smaller / less steep / shallower / lower
			(Line will end with) a lower maximum/final velocity or hit the ground after a longer time	B1	**Allow** ball will have a lower maximum/final velocity or hit the ground after a longer time
			Total	12	

Question			Answer	Marks	Guidance
2	(a)		**Level 3 (5–6 marks)** Clear correct explanation of terms **and** correct comparison of materials *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Clear correct explanation of terms **or** correct comparison of materials **or** has some clear correct explanation of terms and some correct comparison of materials *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Has limited correct explanation of terms **and** limited correct comparison of materials *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.	**B1 x 6**	***Indicative scientific points may include:*** ***Explanation of terms*** • elastic : material returns to original length (when load removed) • plastic: material permanently deformed (when load removed) • brittle: elastic behaviour (only) up to breaking point/ will not deform before breaking • ductile: elastic and plastic regions before the material breaks / able to be (permanently) deformed / stretched / bent without breaking • UTS: maximum (tensile) stress a material can withstand • Young modulus = stress /strain • Young modulus = gradient of stress-strain graph ***Comparison of materials*** • Both have elastic regions • **K** is elastic • **J** has a plastic region, **K** does not have a plastic region • **J** is ductile • **K** is brittle • gradient of **J** is greater than **K** • Young modulus of **J** is greater than **K** • UTS of **J** is greater than **K**
	(b)		(Mass of adult =) 50 kg to 150 kg or W = 500N to 1500 N $\text{Area} = \frac{\text{weight}}{2.3 \times 10^{n}}$ $\text{Area} = \frac{1}{3} \times \frac{\text{weight}}{2.3 \times 10^{6}} = \text{value for area } (\text{m}^2)$	**B1** **C1** **A1**	**Allow** use of 10 for g (since estimate) **Allow ECF** for incorrect weight **Ignore** POT **Allow** one significant figure
			Total	**9**	

Question			Answer	Marks	Guidance
3	(a)	(i)	(Vernier) Calliper or micrometer (screw gauge)	B1	**Not** rule(r)
		(ii)	2.52 ± 0.08	B1 B1	 **Allow** (2.52-2.43 =) 0.09 or (2.59-2.52 =) 0.07
		(iii)	Volume = $\frac{4}{3} \times \pi \times (1.26 \times 10^{-2})^3 = 8.379 \times 10^{-6}$ 8.4×10^{-6} m^2	M1 A0	$\frac{1}{6} \times \pi \times (2.52 \times 10^{-2})^3$ OR $\frac{4}{3} \times \pi \times \left(\frac{2.52 \times 10^{-2}}{2}\right)^3$
		(iv)	$\frac{0.023}{8.4 \times 10^{-6}}$ or 2738 2700 (kg m^{-3}) or 2.7 × 10^3 (kg m^{-3})	C1 A1	**Note** 2745 if using calculator value from **(a)(iii)** **Note** must be two significant figures **Allow** one mark for 2.7 × 10^6 (kg m^{-3})
		(v)	$\frac{1}{23}$ or $\frac{0.08}{2.52}$ or $\frac{0.24}{2.52}$ or 4.3% or 3.2% or 9.5% 14% (13.8%)	C1 A1	**Allow ECF** from **a(ii)** – 3.6% or 10.7% for Δ*d* = 0.09 **Allow** maximum/minimum methods **Note** 13% for Δ*d* = 0.07 or 15% for Δ*d* = 0.09 [ECF 5.5% for Δ*d* = 0.01]
	(b)		Extension = 0.096 – 0.078 or 0.018 m Weight = 0.023 × 9.81 or 0.22563 13 (N m^{-1})	C1 C1 A1	 **Allow** ECF for incorrect mass conversion from **(a)(iv)** **Allow** 12.6 (N m^{-1}) or 12.5 (N m^{-1})
	(c)	(i)	Apparent weight = 0.01 × 13 (= 0.13 N) (Upthrust = 0.226 - 0.13) = 0.10 (N)	C1 A1	**Allow ECF** from **(b)** **Allow** 0.008 ×12.5 **Allow** 0.1 (N) (1sf)
		(ii)	$\rho = \frac{0.10}{9.81 \times 8.4 \times 10^{-6}}$ 1200 (kg m^{-3})	C1 A1	**Allow ECF** from **(c)(i)**
			Total	**15**	

Question			Answer	Marks	Guidance
4	(a)	(i)	$\frac{1}{R} = \frac{1}{60} + \frac{1}{60}$ or $\frac{1}{R} = \frac{1}{60} + \frac{1}{60} + \frac{1}{60}$ or $R = \frac{60}{n}$ or $R = \frac{60 \times 60}{60+60}$ 30 Ω + 20 Ω = 50 Ω	M1 A1	
		(ii)	$\frac{30}{50} \times 9$ or $I = \frac{9}{50} = 0.18$ A 5.4 V	C1 A1	
		(iii)	$\left(I = \frac{5.4}{60} =\right)$ 0.090 A (0.09 × 120 =) 11 C or coulomb	C1 A1 B1	**Allow ECF** from **(a)(ii)** **Allow** 10.8 **Note** 0.18 C scores two marks provided 0.09 A is seen **Note** 21.6 C scores one mark (for the correct unit)
		(iv)	(11 × 5.4 or 0.09 × 5.4 × 120)= 59 or 58 (J)	A1	**Note** 58(.3) if 10.8 C used **Allow ECF** from **(a)(ii)** and/or **(a)(iii)** **Not** 60
	(b)		I = *nAve* or *v* α I larger current through **Y** than **Z** ORA drift velocity in **Y** is 1.5 times drift velocity in **Z** ORA	B1 B1 B1	**Allow** any correct rearrangement of I = *nAve* **Allow** I_Y = 0.090 A <u>and</u> I_Z = 0.060 A OR I_Y / I_Z = 1.5 ORA
	(c)		*n* = number of (free) charge carriers <u>per unit</u> volume / <u>per</u> cubic metre / m^{-3} The larger the value of *n*, the better the conduction / greater the current ORA Copper has a larger *n* than carbon which has a larger *n* than ceramic ORA	B1 B1 B1	**Allow** <u>free</u> electrons for free charge carriers **Not** electrons **Allow** copper is a conductor / most conductive or semiconductor does not conduct as well as copper etc. **Allow** values for *n*
			Total	14	

Question			Answer	Marks	Guidance
5	(a)	(i)	0.45 (m)	B1	
		(ii)	4.0 (m)	B1	**Ignore** significant figures
		(iii)	$\frac{0.5}{4}$ or $\frac{1}{8}$ $(\frac{0.5}{4} \times 2\pi =) \frac{\pi}{4}$ or 0.79 (rad)	C1 A1	**Allow ECF** from (a)(ii) **Note** 0.785
		(iv)	0.45^2 or 0.15^2 or 0.2025 or 0.0225 9	C1 A1	**Allow ECF** from (a)(i) **Allow** one significant figure
	(b)		**Level 3 (5–6 marks)** Clear procedure, measurements **and** analysis *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Some procedure, some measurements **and** some analysis. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** Limited procedure, limited measurements **and** limited analysis *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** No response or no response worthy of credit.	B1 x 6	**Indicative scientific points may include:** **Procedure** • labelled diagram • two loudspeakers OR loudspeaker and double slit • signal generator connected to loudspeaker(s) • microphone and oscilloscope/sound sensor • microphone and oscilloscope/sound sensor moved between loudspeakers • safety precaution (ear defenders) • method to avoid reflections of sound • change frequency and repeat measurements for *x* • *D* >> *a* **Measurements** • frequency determined from oscilloscope/ reading from signal generator • additional detail from use of oscilloscope e.g. time-base to determine period and *f* = 1/*T* • use of rule(r) to measure distances *a*, *D* and *x* • measures over several maxima/minima **Analysis** • rearrangement of equation for *v* or into *y*=*mx* • plot a graph of *x* against 1/*f* or equivalent • straight line through origin confirms relationship • gradient = *vD* / *a* • $v = \frac{a \times \text{gradient}}{D}$.
			Total	12	

Question			Answer	Marks	Guidance
6	(a)	(i)	Threshold frequency is the minimum frequency (of the incident EM waves/photon) to detach / emit / remove / release an electron (from the surface of the silver)	B1	**Allow** electrons **Allow** photoelectron / photoelectrons
		(ii)	$1.1(0) \times 10^{15}$ (Hz)	B1	
		(iii)	$6.63 \times 10^{-34} \times 1.1 \times 10^{15}$ or 7.293×10^{-19} 4.6 (eV)	C1 A1	**Allow** substitution of point from graph into Einstein's equation **Allow** use of gradient as the Planck constant **Note** 4.558… eV
	(b)		Any four from: • electrons may be diffracted by graphite/carbon/atoms/crystal lattice • to produce rings / circular interference fringes • diffraction of electrons occurs when the wavelength is comparable / similar to the gap size • changes in the electron's speed/energy change the size of the ring / interference fringe spacing • electrons have a (de Broglie) wavelength given by $\lambda = h/p$ • reason for the rings as opposed to linear pattern, e.g. graphite atoms are irregularly arranged.	B1x 4	
			Total	**8**	

OCR (Oxford Cambridge and RSA Examinations)
The Triangle Building
Shaftesbury Road
Cambridge
CB2 8EA

OCR Customer Contact Centre

Education and Learning
Telephone: 01223 553998
Facsimile: 01223 552627
Email: general.qualifications@ocr.org.uk

www.ocr.org.uk

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Head office
Telephone: 01223 552552
Facsimile: 01223 552553

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